STATE OF THE ESTUARIES 2

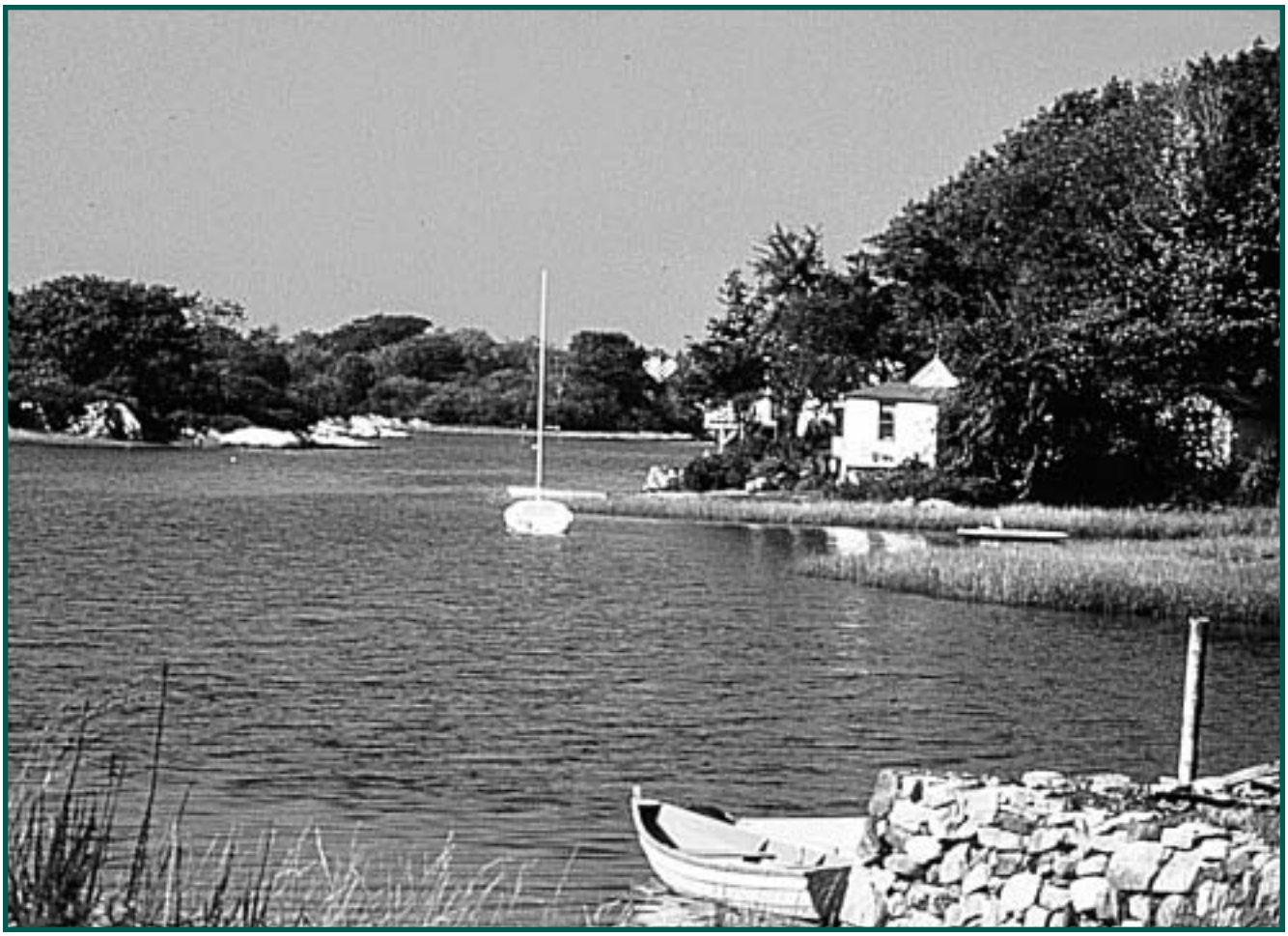
Estuaries are a vital component of the natural, aesthetic, and economic character of coastal New Hampshire. The cultural and natural history of the region has long been shaped by the abundant resources of New Hampshire's estuaries. Archaeological evidence shows that long before European colonization, people were drawn to New Hampshire's estuaries for the bountiful fish, shellfish, and game; to grow crops on the rich soils along the rivers; and to navigate the waterways.

GBNERR

Crommet Creek, Great Bay

The first European settlements in New Hampshire were located at the waters' edge to take advantage of the extraordinary fisheries of the rich estuaries and the nearby Gulf of Maine. Cod, lobster, alewives, sturgeon, menhaden, clams, and oysters sustained the first Europeans and formed the foundation of the early colonial economy. Coastal New Hampshire's link to the estuaries was further strengthened when the forests of the Great Bay watershed were harvested to supply the growing needs of colonial shipbuilding as new boatyards sprang up along the tidewaters. Soon after, enterprising industrialists looked to the tidal rivers and creeks of coastal New Hampshire for waterpower to drive mills and factories. Industry prospered with the combination of abundant waterpower, plentiful natural resources, and access to worldwide markets afforded by tidewater locations.

Today New Hampshire's estuaries still contribute to the economic, aesthetic, and environmental character of our state. However, the very attractions of the coastal location and resources pose a threat due to the affects of population growth and development on the environmental condition of the estuaries that supports the region's prosperity and appeal.



GBNERR

Little Harbor

New Hampshire's estuaries face threats that imperil Seacoast traditions of fishing, shellfishing, and other water-dependent activities. Polluted stormwater runoff, overburdened septic systems, and wastewater treatment facility and industrial discharges, all threaten the environmental quality of our estuaries. These threats represent dangers to regional water quality, as well as to the host of living things that depend on New Hampshire's estuaries for their well-being, and make the estuaries so resource-rich.

The activities of area residents and visitors have profound impacts on the estuarine system. Boats put oil and other pollutants in the water, disturb plant and animal life, and erode banks. Shoreline development removes protective plant cover, disturbs soils, increases runoff, and disrupts wildlife habitat and corridors and scenic views. Population growth and development throughout the region add to stormwater problems and burden wastewater treatment systems.

New Hampshire's estuaries provide a coveted coastal atmosphere and setting for life along the coast, as they have throughout history. Located within an hour of Boston, Manchester, and Portland, this unique and beautiful land- and seascape attracts residents, businesses, and tourists, making the New Hampshire Seacoast one of the fastest-growing areas in New England – and compounding the pressures of development on the estuaries. We must use these resources responsibly, to safeguard this legacy for future generations.

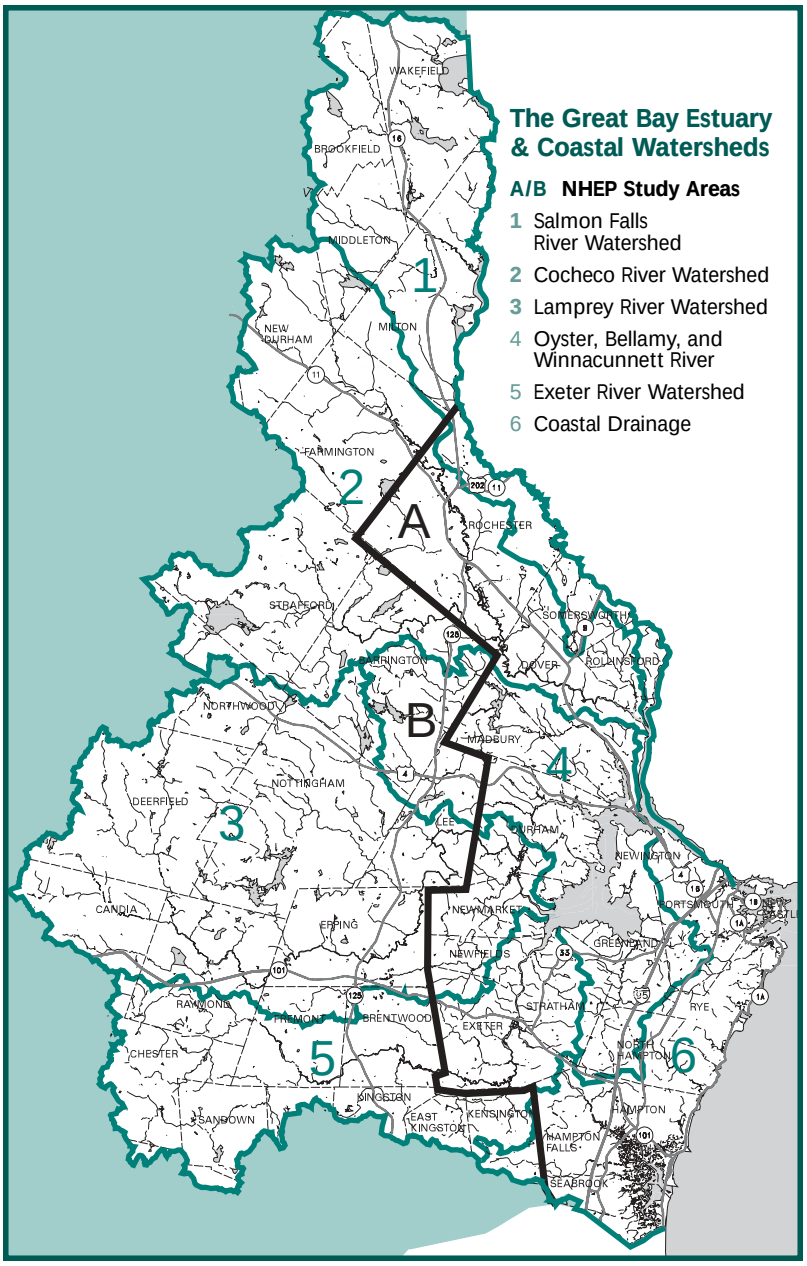
WHAT IS AN ESTUARY?

An estuary is a semi-enclosed embayment where freshwaters from rivers and streams mix with saltwater from the ocean. Estuaries are extraordinarily productive and diverse environments because of a unique set of conditions that create unusually nutrient-rich, protected waters. Many biologists consider estuaries among the most productive environments on earth.

Above: the Hampton-Seabrook Estuary

Left: South and North Mill Ponds, Portsmouth

JEL/UNH



Tidal Tributaries: Salmon Falls/Piscataqua River, Cocheco River, Bellamy River, Oyster River, Lamprey River, Squamscott River, Winnicut River.

NEW HAMPSHIRE'S ESTUARIES

With its Old Man of the Mountains icon, New Hampshire is more often associated with the White Mountains than with marine or estuarine habitat. However, New Hampshire has over 230 miles of sensitive tidal shoreline in addition to 18 miles of open-ocean coastline on the Gulf of Maine.

New Hampshire's estuaries are a varied collection of bays, tidal rivers, and salt marsh systems. The Great Bay and Hampton-Seabrook estuaries are the largest distinct estuaries in New Hampshire. Great Bay, Little Bay, the Squamscott River, and the tidal portions of the Lamprey, Oyster, Bellamy, Cocheco, and Salmon Falls Rivers, the Piscataqua River, Little Harbor, Rye Harbor, Hampton-Seabrook Harbor, and many smaller tidal tributaries are all part of New Hampshire's diverse estuarine systems.

Project Area

These watershed areas encompass the New Hampshire Estuaries Project study area which includes 43 municipalities, and are the focus of the actions included in the *Management Plan*. (See map of the New Hampshire estuaries watersheds on the inside cover of this *Plan*.)

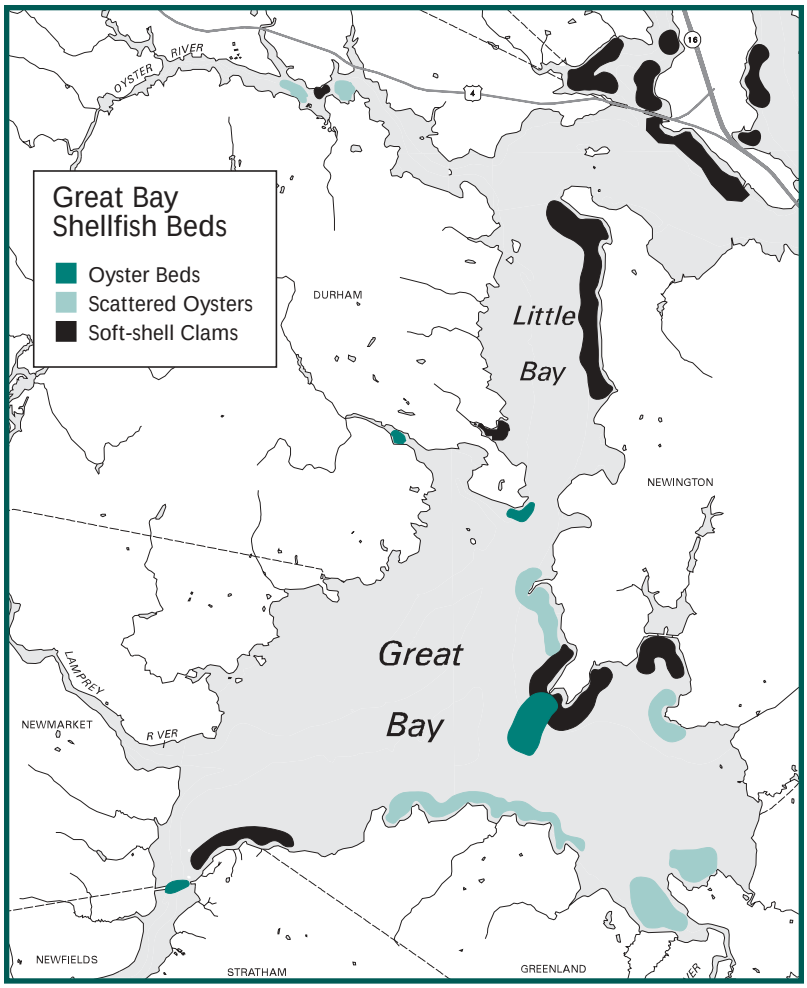
The entire NHEP area of 43 towns is divided into Zone A and Zone B. The 19 communities of Zone A include all municipalities with tidal shoreline, plus Rochester and Somersworth. Many NHEP Action Plans focus on Zone A cities and towns since they have both the greatest impact and the greatest stake in the environmental health of the estuaries.

Great Bay

The Great Bay Estuary covers 17 square miles with nearly 150 miles of tidal shoreline. Great Bay is unusual because of its inland location, more than five miles up the Piscataqua River from the ocean. Due to its inland location, Great Bay's tidal exchange with the ocean is slow, requiring up to 18 days or 36 tide cycles for water entering the head of the estuary to move to the ocean. With much of Great Bay's shorelines still largely undeveloped, it has

been called “the unknown treasure of the New Hampshire Seacoast.”

Recreational shellfishers harvest oysters and clams; fishing enthusiasts pursue striped bass, bluefish, herring, or smelt; lobstering is a commercial and recreational activity, and eels are trapped for bait and for export. Birders from all over the country and the world come to view migratory birds against this picturesque backdrop. Great Bay is the state’s principal waterfowl overwintering site, and a focus area for the North American Waterfowl Management Plan. The Great Bay National Wildlife Refuge was established on just over 1,000 acres of the former Pease Air Force Base.

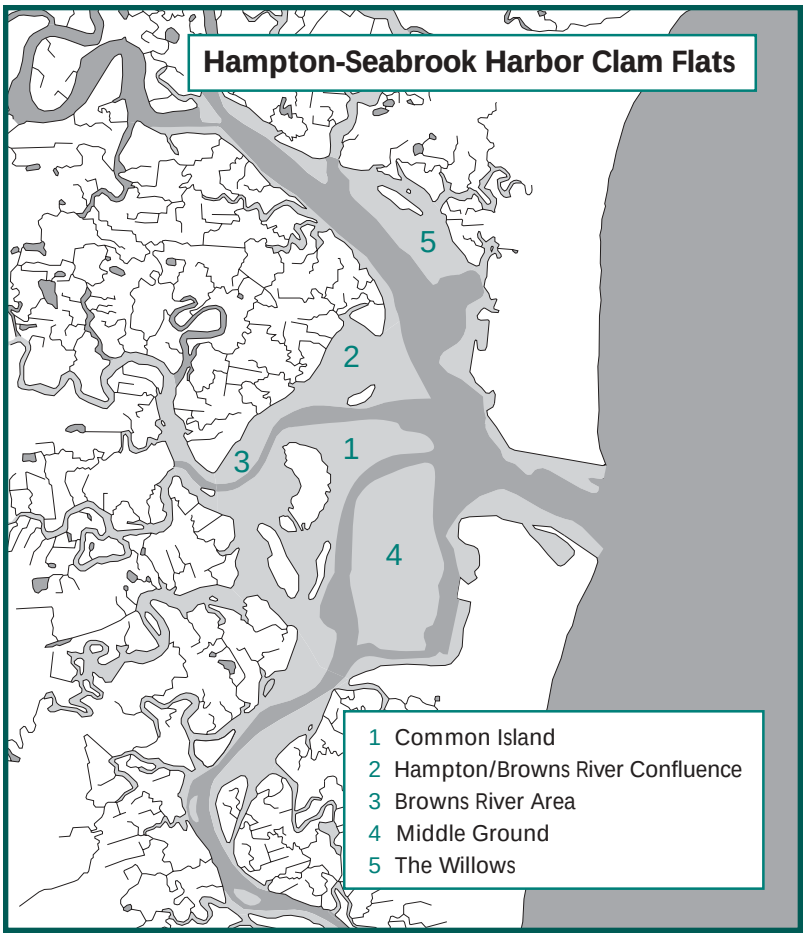


Great Bay’s relatively undisturbed natural setting attracts scientists, researchers, and teachers interested in estuarine and marine processes, or salt marsh, mudflat, eelgrass, and other habitats. The University of New Hampshire, a land-grant, sea-grant, and space-grant university, is located in Durham within the Oyster River watershed of the Great Bay estuarine system. The University of New Hampshire and New Hampshire’s Seacoast have become a nationally and internationally recognized center for research, teaching, and development of practical applications of marine and estuarine science and technology.

Recognized as an estuarine system of national significance, Great Bay is the site of the Great Bay National Estuarine Research Reserve and the University of New Hampshire’s Jackson Estuarine Laboratory. The National Oceanic and Atmospheric Administration recently joined with the University of New Hampshire to establish the Cooperative Institute for Coastal and Estuarine Environmental Technology at UNH. The new Joint Hydrographic Center and the Center for Coastal and Ocean Mapping at UNH have drawn the top researchers in this emerging field.

Hampton-Seabrook Harbor

Hampton-Seabrook Harbor encompasses 475 acres of water at high tide. Characterized by extensive salt marshes and separated from the ocean by a series of barrier beaches, this estuary represents a more typical estuarine system. This estuary’s 5,000 acres of contiguous salt marsh make it by far the largest salt marsh in the state. Hampton-Seabrook Harbor provides the backdrop for Hampton Beach, one of the busiest tourist attractions and vacation spots in the state. It is also the site of the North Atlantic Energy Service Corporation’s Seabrook Station, a nuclear-powered electric generation facility.



Although surrounded by the busy seacoast communities of Seabrook, Hampton, Hampton Falls, and North Hampton, the Hampton-Seabrook Estuary hosts the best clamming in the state. Several thousand New Hampshire residents purchase shellfish licenses each year, most to dig the softshell or steamer clams of the Hampton-Seabrook Estuary.

Estuarine Watersheds

New Hampshire's estuaries are linked to the surrounding upland areas by the freshwater that drains through the Great Bay and coastal watersheds. On its course to the ocean, water collects a variety of materials of both natural and human origin, with profound impacts on the estuaries.

The 43 cities and towns in the 980 square-mile Great Bay and coastal watersheds are linked by water. From rainwater to groundwater, puddles to tidal rivers, across municipal and political boundaries, water moves unerringly through these watersheds along its course to the ocean. Each watershed resident is responsible for safeguarding our mutual interest in the water and natural character of the area, and for leaving a positive environmental legacy of improving the environmental condition of New Hampshire's estuaries.

New Hampshire has benefitted from its close association with the estuaries, but the estuaries themselves have paid a dear price for this association. Rivers that once supported substantial runs of anadromous fish (species that live in saltwater but spawn in freshwater), such as Atlantic salmon, American shad, and alewives and other river herring, now host minimal returns or none at all. Over-harvest and poor estuarine water quality have contributed to declines of seasonal fish populations that depend on estuaries as spawning and nursery grounds.

For many years, our estuaries were used as convenient dumping grounds for sewage and industrial wastes. The industrial history of the Great Bay and coastal watersheds are chronicled in the toxic materials trapped in sediments throughout the estuaries. Dams that once ran mills and factories now restrict freshwater flow and collect sediments. Much of New Hampshire's valuable salt marsh habitat has been lost or degraded to some degree by filling and constriction of tidal flows for roads and development, and by historic ditching and draining for harvesting salt marsh hay and to control mosquitoes. Today we are responsible for dealing with both historic and present-day sources of estuarine contamination.

A REPORT CARD ON NEW HAMPSHIRE'S ESTUARIES

The good news is that our estuaries remain among New Hampshire's crown jewels. The estuaries are a natural and cultural resource treasure. After a long history of sewage and industrial pollution, water quality has improved significantly over the last two decades. The estuaries contain valuable and productive habitats that support diverse species, some rare or endangered.

The bad news is that work remains to be done. Cleaning up the water of the estuaries is critical to the health of resources such as shellfish, and for people to use and enjoy estuarine resources.

The priority water quality problems include:

- Bacterial contamination from runoff from impervious areas, waste water treatment facilities (WWTFs) overloading and malfunctions, illegal direct discharges and cross-connections, and faulty septic systems;
- Nutrient contamination from WWTFs and non-point sources such as tributaries, surface runoff, septic systems, etc.;
- Toxic contaminants from historic industrial sites, oil spills, industrial and municipal wastewater, and stormwater runoff;
- Sediments from upland watersheds or rivers from runoff.

The priority living resource problems include:

- Oyster population declines
- Clam density declines
- Loss or fragmentation of wildlife habitat
- Degraded salt marshes

The management approaches for addressing these problems include:

- Stormwater management
- Elimination or reduction of pollution from WWTFs, cross-connections, and illegal discharges
- Outreach to local and regional planners
- Shellfish resource and sanitation management
- Land conservation
- Shoreland protection
- Limiting sprawl development

Habitat Protection

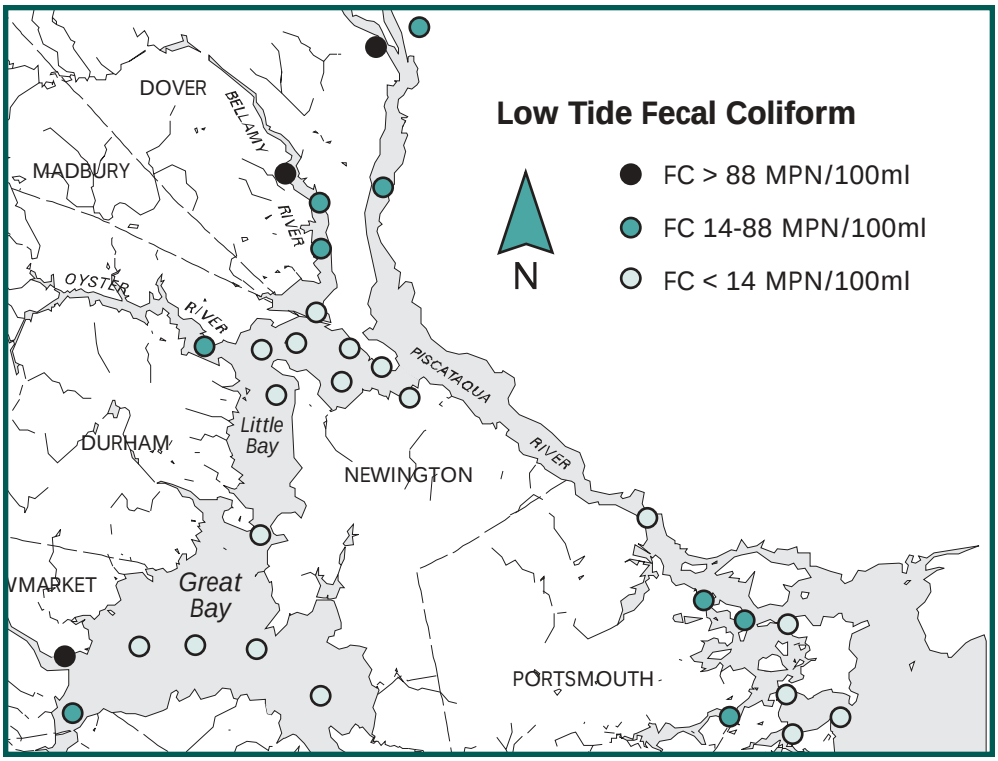
Improving water quality, and improving and restoring habitats and resource management will help address most of these problems. Growth and development present the greatest environmental challenges to the estuaries. In addition to solving existing problems, planning and preventive actions in the estuarine watersheds are needed to protect the estuaries from the increasing pressures of growth and development.

Water Quality

Water quality, an important indicator of environmental health, has a profound influence on the condition of nearly all estuarine habitats, plants, and animals. Water transports and redistributes harmful bacteria, excess nutrients, and toxic materials. Stormwater runoff contributes to degraded water quality and threatens many natural resources throughout the coastal watersheds.

Stormwater contaminates New Hampshire's estuarine waters with pathogenic bacteria and viruses, nutrients, sediment, trace metals and other toxins from roadways, parking lots, roofs, and residential and agricultural areas. Runoff from impervious surfaces carries bacteria and sediments, and is a significant source of trace metal and toxic organic contaminants. Storm runoff from disturbed areas carries sediments and associated nutrients. Runoff resulting from rainfall and snowmelt events in urban and urbanizing areas is the most common source of bacterial contamination in New Hampshire estuaries. This is due to a combination of inflow and infiltration to sewer pipes, overloaded wastewater treatment plants and combined sewer overflows (CSOs), and non-point source runoff. Bacterial contamination is the chief cause of shellfish bed closures.

Non-point source pollution (NPS) is water pollution that comes from diffuse sources and is carried to surface water by rainfall, snowmelt, or groundwater movement. NH DES estimates that over 90% of impairments to lakes, ponds,



Average levels, 1988-98. Levels greater than 14MPN/100ml lead to shellfish harvesting closures.

rivers, and streams statewide are due to non-point sources. Water quality monitoring studies show that non-point sources are a significant problem in New Hampshire coastal waters and tributaries, especially for bacterial contamination. Stormwater runoff can collect, transport, and deposit fecal bacteria, excess nutrients, oils and greases, toxic contaminants from pesticide and herbicide applications, toxic metals, and sediments eroded from shorelines and construction sites. Stormwater runoff, which can include storm sewer cross-connections, is considered the number one water quality problem facing the Seacoast region, and is a factor in keeping some shellfish beds closed.

Point source pollution, typified by both permitted and illegal direct discharges, is a continuing challenge to the environmental character of the coastal watersheds. Wastewater treatment facilities, industrial discharges, and power plants are the most common point sources. While these discharges are closely monitored and regulated through state and federal permitting processes, the demands of regional economic and residential growth challenge wastewater treatment plant capacities, spur demand for electric power, and accelerate the production of industrial waste products. Point source pollution, often characterized by continual low level contaminant loading, tends to increase proportionally with regional growth.

New Hampshire's estuaries are also subject to contamination from the air. **Atmospheric deposition** from both outside and within the state's borders is now recognized as an important source of pollutants to surface waters across the state. Lead, mercury, and nitrogen compounds are deposited directly into surface waters or onto upland watershed areas and delivered to the estuaries in stormwater runoff.

COASTAL AIR QUALITY

An ozone monitoring station at Rye Harbor no longer records levels of ozone that exceed the standards set by the US EPA. Earlier in the 1990s, ozone levels regularly violated EPA's one-hour ozone standard, indicating that the New Hampshire Seacoast, including Great Bay Estuary, had high tropospheric ozone levels. All of Rockingham County was within the ozone non-attainment region, therefore the estuary was in ozone non-attainment. New Hampshire no longer has any areas in violation of this standard.

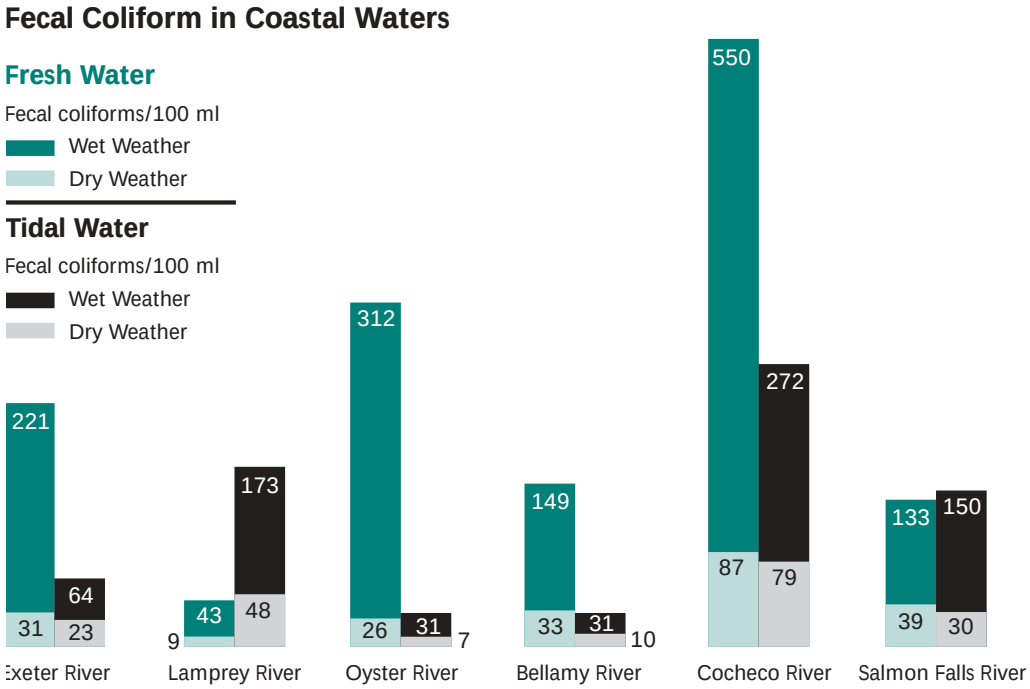
However, EPA recently created a more stringent ozone standard, based on an eight-hour average. Once EPA designates areas of attainment and non-attainment New Hampshire may have some areas that do not meet the eight-hour ozone standard. Air pollution presents health hazards to people and to wildlife, and pollutes surface water as atmospheric deposition. Still, citizens attending NHEP public meetings ranked air quality low in priority, probably because most Seacoast air pollution is beyond the reach of local control.

New Hampshire and other East Coast states affected by ozone pollution carried by air currents from other regions have joined together to form the Ozone Transport Assessment Group (OTAG) to study the problem and seek appropriate actions. Nitrogen oxides (NOx) and volatile organic compounds (VOCs) react together in sunlight to produce low level, or tropospheric, ozone. OTAG studies indicate that NOx is the limiting factor in the photoreaction of NOx and VOC. Of all the NOx generated in New Hampshire, 63% is from mobile sources (motor vehicles) while 24% is from point sources and 13% is from area sources. OTAG data also indicate that the majority of New Hampshire's ozone results from NOx emissions that occur to the south and west, or "upwind." The NH DES has petitioned EPA to mitigate the upwind emissions of NOx by requiring upwind sources to reduce their Nox emissions, in an attempt to reduce New Hampshire's ambient tropospheric ozone concentrations.

The Ozone Transport Assessment Group (OTAG) has completed their policy recommendations and submitted them to EPA for their action. Based on OTAG's data, EPA has proposed new NOx emissions figures that are directed at sources upwind of New Hampshire.

NH DES has also convened a Global Climate Change Workgroup representing a wide range of interests from virtually every sector throughout the state. Their charge is to suggest measures to NH DES to reduce emissions of greenhouse gases cost effectively and without detriment to the economy. There are currently no regulations at the state or federal level aimed specifically at controlling greenhouse gases.

Geometric mean fecal coliforms (colonies/100 ml) in water collected during dry weather and storm events for three consecutive years in tributaries to the Great Bay Estuary: 1993-96.



Bacteria

Fecal coliform bacteria in water is a warning of sewage contamination and may indicate the presence of disease-causing organisms. Found throughout New Hampshire's estuaries, fecal bacteria come from a variety of sources: faulty septic systems, overboard-marine toilet discharges, wastewater treatment facility overflows, and sanitary sewer-stormwater system cross connections. Cross connections occur when sanitary sewers leak – or are illegally connected – into stormwater systems, causing discharge of sewage-contaminated stormwater directly into surface waters. Waterfowl, pet, and livestock waste can also contribute to bacterial contamination. Because of the public health risks associated with these bacteria, fecal coliform levels are routinely monitored throughout coastal New Hampshire in both wet and dry weather. Shellfish beds are closed to harvesting when fecal coliform levels in water exceed 14 per 100 ml.

Although coliform counts in tidal rivers have been reduced dramatically since 1960, water quality sampling throughout the Great Bay Estuary tracks a pattern of elevated counts coming from urban runoff and wastewater treatment plants. Despite significant improvements in recent decades, wastewater treatment facilities (WWTF) in the Seacoast do not meet their required treatment standards 100% of the time. Factors affecting WWTF performance include equipment problems, operational changes, operator errors, storm events, and changes in waste stream. The most severe incidences of bacterial contamination from WWTFs follow rain events that cause systems to overflow.

Bacterial concentrations in New Hampshire estuaries are highest during or immediately after rainfall, indicating that much of the bacterial pollution comes from contaminated stormwater runoff. Storm-associated bacterial pollution has been found in all the primary rivers in the Great Bay watershed, with the highest levels found in the Cocheco River.

High background concentrations of bacteria in the Cocheco River under dry-weather conditions suggest ongoing sewage pollution. Cross-connections that add untreated waste to stormwater systems through cracked pipes and illegal connections are the most likely sources of dry-weather bacterial pollution. Stormwater systems then deliver contaminated water directly to the Cocheco River and streams flowing into Great Bay.

Nutrients

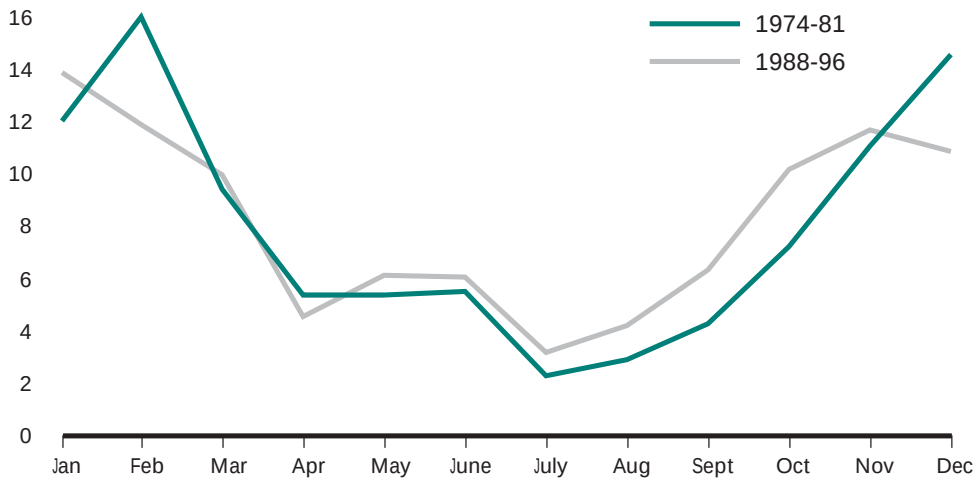
Estuarine systems are especially sensitive to excess nitrogen. Nitrogen is a naturally occurring nutrient essential for plants and algae. But too much nitrogen can promote unrestrained growth of nuisance algae. As these algae blooms die and decompose, they rob the water of oxygen, harming or killing estuarine and marine life.

Nutrient loading is the continual addition of nutrients from natural and human sources. The nutrient load to Great Bay from its tributary rivers comes from both point and non-point sources, and from atmospheric deposition. Nutrient loading occurs in all New Hampshire estuaries and their tributaries. Evidence suggests that nutrient concentrations within the main area of Great Bay have not changed significantly over the past twenty years. No widespread eutrophication effects have been observed. However, local isolated incidents of reduced oxygen levels and intense phytoplankton blooms have been observed in some freshwater tributaries of the Great Bay Estuary. Documented effects of phytoplankton blooms in other areas are rare. Thus, eutrophication and related impacts do not appear to be an imminent widespread problem.

No data is available on nutrient loading in Hampton-Seabrook, Rye, and Little harbors. But given the 80% tidal exchange twice a day, excess nutrients are not believed to be a problem.

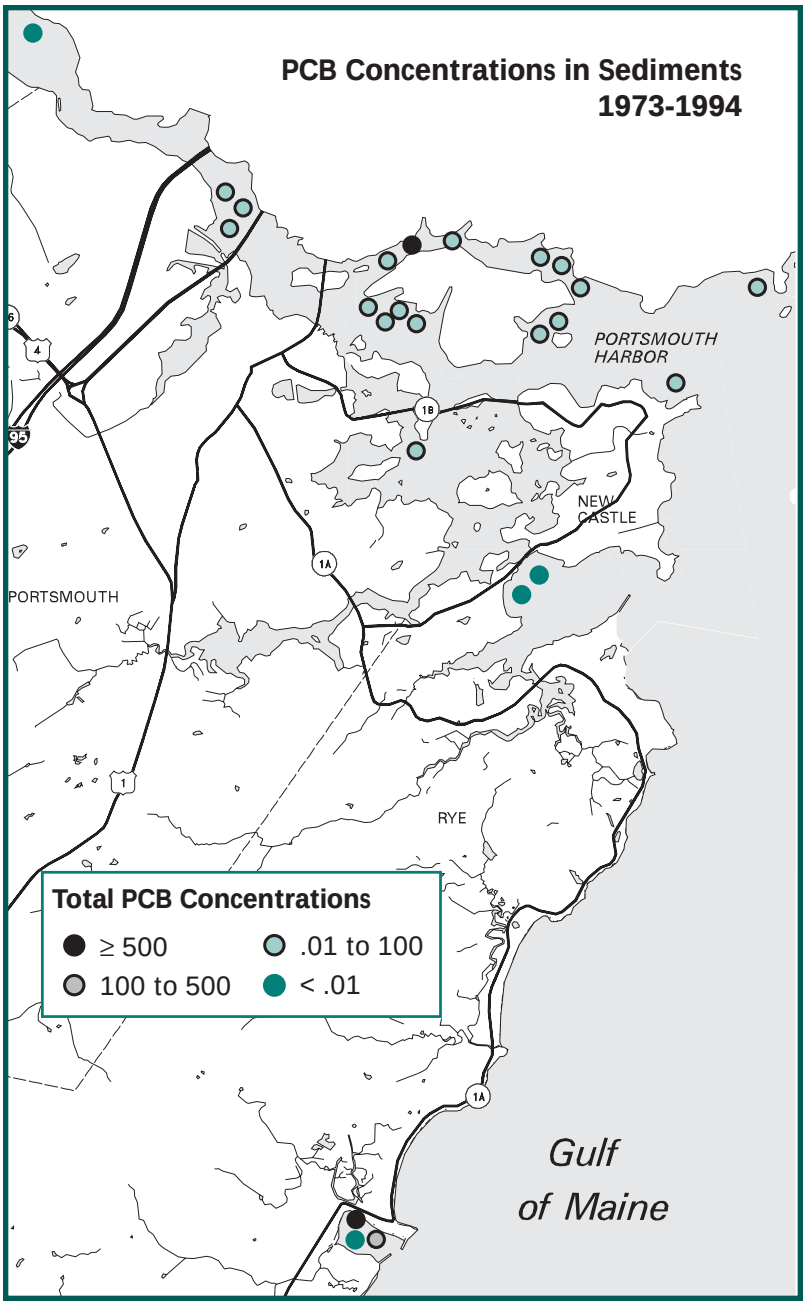
However, sources of nutrient contaminants such as wastewater treatment facility effluent, lawn fertilizer residue, septic systems, and runoff from impervious surfaces, will increase with human population growth and development pressures. For this reason, it is important to continue to monitor nutrient levels in New Hampshire's estuaries as a safeguard against gross nutrient contamination.

Dissolved Inorganic Nitrogen



Monthly mean dissolved inorganic nitrogen at Adams Point in Great Bay for the years 1973-81 and 1988-96.

Nutrient concentrations within the main area of Great Bay have not changed significantly over the past 20 years.



Spatial distribution of PCB concentrations showing hot spots in Hampton Harbor and near the Portsmouth Naval Shipyard.

Toxic Materials

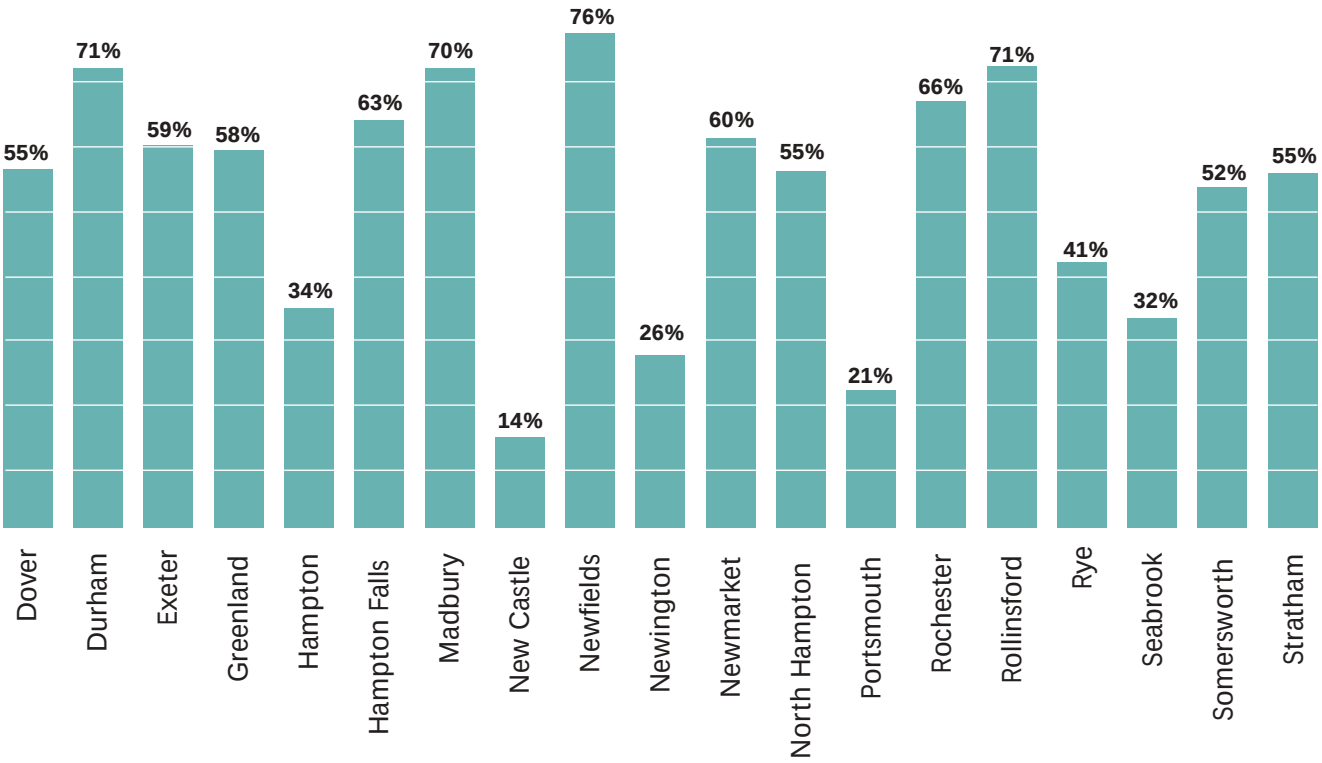
Heavy metal and toxic organic compounds are found throughout New Hampshire's estuaries. The Portsmouth Naval Shipyard, the former Pease Air Force Base, and a few other locations exhibit particularly elevated concentrations of some toxic contaminants. The most common toxic contaminants are chromium, lead, mercury, copper, zinc, and PCBs. A warning has been issued against consuming lobster tomalley due to PCB levels. DDT and other organic pollutants are present at elevated levels at some sites, but not at concentrations of concern to humans and other living things in most cases. Concentrations may warrant limited, localized concern, but remediation is complicated, with issues of stirring up and redistributing contaminants, disposing of dredgespoil, etc.

From colonial times mills, tanneries, and factories were built on the banks of our coastal rivers for their waterpower, shipping access, and easy waste disposal. A legacy of toxic contamination remains stored in the fine-grained sediments dispersed throughout the estuaries. Currently small doses of toxins enter the estuaries from permitted and monitored discharges, pesticides, atmospheric deposition, and occasional oil spills. Other suspected sources include municipal discharges, stormwater runoff, and groundwater contaminated with leachate from hazardous waste disposal sites.

Land Use and Regional Growth

Many of the threats to the environmental character of our estuaries are the direct result of human activities, including development of land for residential, commercial, industrial, and other uses. Continued population growth and development in the coastal region will add more impervious surfaces – paved areas, buildings, etc. – and add to the potential for increased stormwater-related, non-point source pollution. Negative impacts on both water quality and living resources can be managed through careful planning of development. New Hampshire communities – especially those with urbanized areas near surface waters – need technologies that effectively treat runoff.

Potentially Developable Land in the 19 Coastal New Hampshire Municipalities, 1998



The greatest threats to water quality, habitat, and quality of life from land use and development are:

See p. 5-2 for a map of potentially developable land described above.

Impervious surfaces created in the built environment add to the volume and velocity of stormwater, sending more pollutants and sediments through drains and tributaries or directly into the estuaries.

Shoreland development can destroy the natural buffering of vegetated and wooded soils against erosion and runoff, destroys wildlife habitat and travel corridors, and alters scenic vistas from both shore and water.

Sprawl development fragments wildlife habitat and corridors and reduces open space.

In the 19 New Hampshire towns with tidal shoreline (NHEP Zone A), approximately 30% of the land is currently developed. Studies indicate an additional remaining 15% is undevelopable due to permanent conservation and wetlands restrictions. Up to 55% of the total land area within these towns could potentially be developed, i.e., land with no legal restrictions or physical constraints that would prevent development. Future development will magnify runoff-associated problems and create new natural resource management issues by increasing impervious surfaces and destroying or degrading riparian and wetland habitats.

Shorelands are under particularly intense residential development pressure because many people desire to live by water in a coastal area. Shoreland development can impair a riparian area's ability to protect water quality and

provide habitat to several important wildlife species. Recent analyses indicate 35% of New Hampshire's tidal shoreland – defined as a strip of land extending 300 feet from the water's edge – is already developed. Just 16% of tidal shoreland is permanently protected, with an additional 21% likely to remain undeveloped because of natural resource constraints. But approximately 28% of the state's tidal shorelands remain open and developable. Both shoreland preservation and conscientious development of shorelands require careful planning and attention.

Natural Resources

The rich diversity of habitats found in New Hampshire's estuaries support a great variety of plants, animals, and fish, including rare and endangered species. Botanists have identified 67 rare plant species within the Great Bay and coastal watersheds, a dozen associated with estuarine environments.

These estuarine habitats include salt marshes, eelgrass beds, algal beds, rocky intertidal areas, barrier beaches, dunes, mud and sandflats, clam and oyster beds, and subtidal bottom habitats with substrate ranging from mud to cobble and boulders. The NH Coastal Program and the UNH Complex Systems Research Center are developing geographic information system (GIS) data to map the location and extent of these various habitat areas.

Protecting and buffering the variety of habitats found throughout the Great Bay and coastal watersheds safeguards the area's unique natural character, and supports the survival of the species that use and depend on these habitats. Preserving and protecting these important habitats demands careful planning as development pressures grow and human uses within the watershed increase.

Land Use Regulations for 19 Estuarine Communities in Coastal New Hampshire

Regulation	Number of Towns with Regulations	% Towns with Regulations
Master Plan	19	100%
Erosion Control	18	95%
Stormwater Control	17	89%
Wetland Protection	17	89%
Septic Control	15	79%
Gravel Extraction	14	74%
Open Space	13	68%
Floodplain Ordinances	13	68%
Aquifer Protection	12	63%
Shoreland Protection	12	63%
Chemicals/Toxics	8	42%
Growth Management	8	42%
Water Resource Management Protection Plan	5	26%
Marinas	4	21%
Impact Studies	3	16%
Biosolids	2	11%
Review Committees	2	11%

THE NHEP BASE PROGRAM ANALYSIS AND TECHNICAL CHARACTERIZATION

See Chapter 9 for more detailed recommendations from the Base Programs Analysis.

The National Estuaries Program requires a *Base Program Analysis* (BPA) of existing local and state regulatory and management programs for protecting estuarine resources. Gathering this background information was an essential step for the NHEP in designing a realistic and workable *Management Plan*. The NHEP Base Program Analysis, *Regulation and Management of New Hampshire's Estuaries,* evaluated the effectiveness of the existing framework, and provided valuable insight for identifying priority issues and management road-blocks.

The Water Quality; Land Use, Development, and Habitat Protection; Shellfish Resources; and Habitat Restoration chapters of the NHEP *Management Plan* and the Action Plans each have a technical or scientific component taken from *A Technical Characterization of Estuarine and Coastal New Hampshire,* and a regulatory and management section derived from the BPA. The *Technical Characterization* is a detailed review and analysis of current scientific research and knowledge of New Hampshire's estuaries, and is the source for most of the scientific and technical information contained in this *Management Plan*. Both the *Base Program Analysis* and the *Technical Characterization* are available from the NHEP.

The *BPA* found a reasonably strong regulatory framework for natural resource protection of the estuaries. Programs for shoreland and wetland protection are sound, as are the point source permit program and septic regulations. While regulations for living resource conservation are adequate, follow through is limited in some cases.

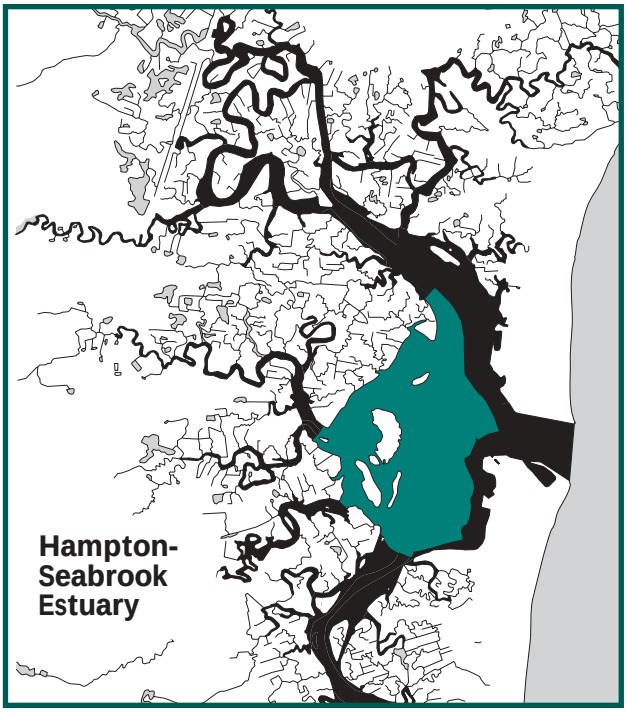
Most other regulatory programs rely on voluntary efforts and Best Management Practices (BMPs) to protect water quality. The effectiveness of this approach depends on BMPs keeping up with constant progress in treatment technologies and scientific understanding. Non-point source and stormwater control BMPs are currently being reviewed and updated.

The BPA identified several additional regulatory and management shortcomings. State stormwater and erosion control regulations apply only when areas of 100,000 square feet or more are disturbed (50,000 square feet in protected shoreland). Shoreland regulations are complicated. Wetlands mitigation practices lack clarity. Protection for vernal pools and wetland drainages is limited. NH Department of Transportation policy on site disturbances and stormwater runoff is unclear. A limited number of communities have used local regulations to address some of the state-level gaps, such as shoreland protection and stormwater and erosion controls.

Regulatory enforcement and site-specific monitoring are also important estuarine management issues. For example, current septic system maintenance and performance requirements are often unenforceable due to the large numbers of systems in each community. Enforcement of local regulations and adequate on-site monitoring can be an administrative burden for volunteer, part-time municipal officials.

1998 Shellfish Water Classifications

Open Closed



Open Closed

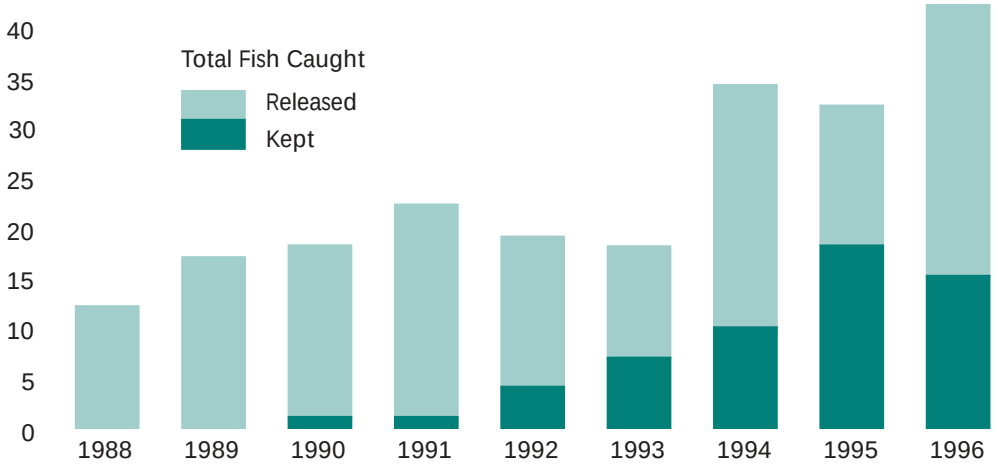
Shellfish Resources

Shellfish in New Hampshire are limited to recreational harvest only, because the state does not have a US Food & Drug Administration approved program for commercial harvesting. Shellfish harvest is a popular recreational pursuit in New Hampshire. However, oyster resources in the Great Bay Estuary have declined in recent years. From 1991 to 1996 oyster density reductions in three beds of recreational importance ranged from 42% to 69%. Other oyster beds have lost significant bed acreage, especially in the Oyster and Bellamy rivers. Oyster harvests reflect these declines: a 1991 study estimated a total harvest of 5,000 bushels of oysters by 1,000 license holders, but by 1997 the estimated harvest had declined to 2,700 bushels by 661 harvesters. Predation, limited availability of suitable larvae-attachment substrate, disease, harvest pressure, and a variety of management issues are likely factors in these declines.

Softshell clam resources in the Hampton-Seabrook Estuary are well documented. Adult populations on three particular flats of the estuary peaked in abundance in the early-to-mid 1980s, then declined sharply through the late 1980s. This decline was most likely due to intense recreational and illegal harvest pressure.

After the flats were closed to harvesting in the late 1980s, adult clam densities began to recover. Conditional reopening of the flats to harvest in 1994 appears not to have significantly affected the resource. From 1990 to 1995 adult clam densities quadrupled on the Middle Ground flat, while Common Island densities remained essentially unchanged. Clam densities in the Hampton River decreased by 50%. One suspected cause of this decrease is a lethal form of leukemia in clams. Little information is available on the softshell clam resources of the Great Bay Estuary and the Little Harbor-Back Channel area.

Tagged Striped Bass Catches



Striped bass caught in New Hampshire with U.S. Fish and Wildlife Service tags: 1988-96.

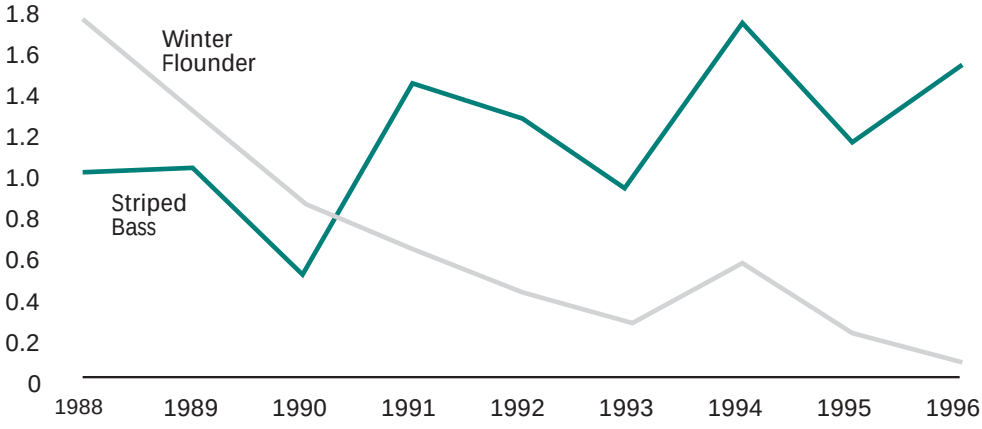
Finfish

A region-wide moratorium and subsequent harvest restrictions on striped bass in the 1980s and 1990s have resulted in dramatic gains in the seasonal occurrence of stripers in New Hampshire waters. Catches of both legal and undersized striped bass tagged by the U.S. Fish and Wildlife Service have increased steadily since 1988. Biologists and anglers generally confirm that fish of all sizes have increased in abundance.

Recreational anglers have not enjoyed this same abundance with winter flounder. Catch per unit effort declined steadily from 1988 to 1993, rose briefly in 1994 and 1995, and then decreased again in 1996. Although juvenile fish appear abundant in the estuaries, adult populations have declined due to commercial harvest pressure in the Gulf of Maine. Commercial landings of winter flounder show a similar, steady decline.

Rainbow smelt catches have varied greatly at several locations in the Great Bay Estuary – peaking in the late 1980s, declining sharply in the early 1990s, and increasing in the mid 1990s. From 1975 to 1996 spring returns of river herring (alewife and blueback) declined in the Exeter, Lamprey, and Taylor rivers, but increased in the Oyster and Cocheco rivers.

Finfish Catches



Catch per trip of striped bass and winter flounder. Based on survey information.

Whimbrel

Waterfowl and Shorebirds

The Seacoast is the principal wintering location for waterfowl in New Hampshire, with 75% of the state's overwintering waterfowl found on Great Bay. State, federal, and locally controlled reserves and sanctuaries in the Great Bay area provide over 6,300 acres of wetlands salt marsh and upland habitat. As a result, Great Bay is an important destination for birders interested in a variety of waterfowl and shorebirds. Great Bay is also a focus area for the North American Waterfowl Management Plan. The Great Bay National Estuarine Research Reserve lists over 170 species by season and abundance on its checklist of the birds of Great Bay. A recent mid-winter survey recorded mallards, black ducks, greater and lesser scaup, goldeneye, bufflehead, red-breasted mergansers, and Canada geese as the predominant waterfowl.

Salt Marsh

The 5,000-acre salt marsh of the Hampton-Seabrook Estuary is the largest contiguous salt marsh in the state. Tidal marshes of the Great Bay Estuary total 2,230 acres, with the most extensive salt marshes found along the lower Piscataqua River, the Squamscott River, and Great Bay itself. The fringing marshes of the Great Bay Estuary wind along tidal shorelines between the low tide line and adjacent upland areas, wherever the soils, elevations, and tidal action are favorable.

The Hampton-Seabrook Estuary

GBNERR

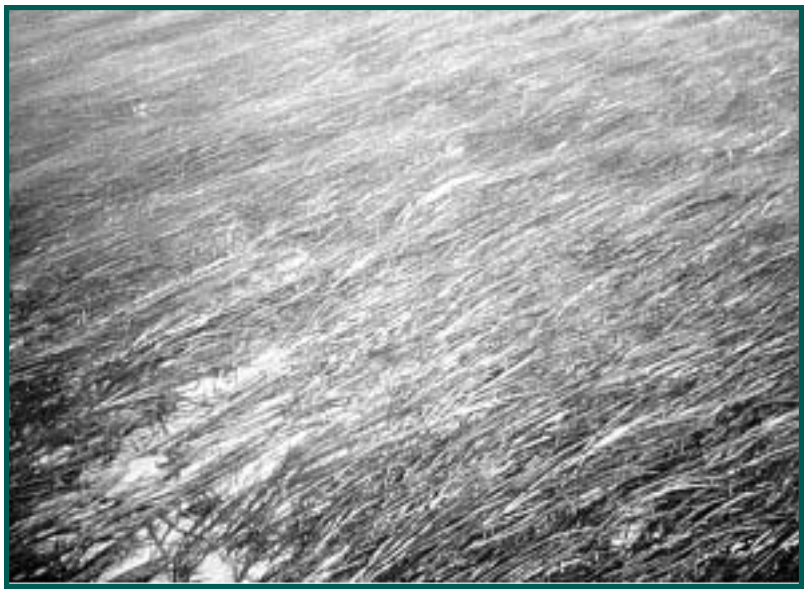
MORRISON

Nearly all salt marshes in New Hampshire were subjected to ditching and draining at one time or another into the first half of this century, in attempts to control mosquitoes or increase harvest of salt marsh hay. Present salt marsh acreage in the state is half of what it once was, with most of the lost acreage filled for residential and industrial development and road or rail construction. Total salt marsh acreage has remained the same over the past decade. However, past development of salt marshes and road and railroad crossings have restricted water circulation and tidal flow within the remaining marshes. These changes in the natural tidal flow have degraded salt marsh function, with impacts including growth of invasive species such as purple loosestrife and *Phragmites australis* or common reed.

Recently a number of salt marshes in New Hampshire have been successfully restored by re-establishing tidal flow and freshwater exchange. Most of these projects have re-established tidal flow and exchange to marshes where tides were restricted by undersized or damaged culverts, water control structures, and/or berms of debris or dredge spoil. Recovery of marsh functions and habitat has been rapid and successful. By 1999 the collaborative efforts of many different agencies and landowners had restored or enhanced over 430 acres of salt marsh in New Hampshire.

Eelgrass

Eelgrass beds or meadows form subtidal and intertidal seagrass habitats which cover the greatest area of all habitat types in the Great Bay Estuary. Eelgrass habitats are important as breeding and nursery grounds for finfish, shellfish, and other invertebrates, and as feeding grounds for many fish, invertebrates, and birds. Eelgrass stabilizes bottom sediments, and may also filter nutrients, suspended sediments, and contaminants from estuarine waters.



Eelgrass

Eelgrass wasting disease (caused by the myxomycete *laburinthula sp.)* was first recognized in Great Bay in the 1940s. In the late 1980s wasting disease caused dramatic eelgrass declines in the Great Bay Estuary, arousing great concern into the early 1990s. However, historical eelgrass beds have made an impressive recovery of acreage and densities, and new beds have been observed in areas previously devoid of eelgrass. While overall the resource is improving, recovery of lost eelgrass areas has been significantly slower in Little Bay.

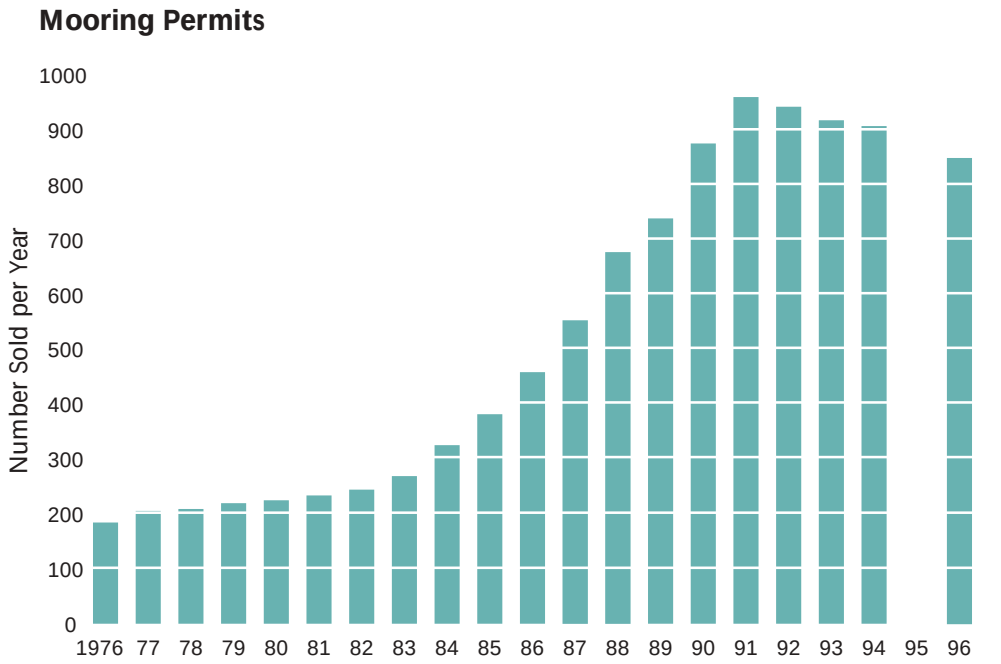
Eelgrass restoration efforts have been conducted at several sites in the Great Bay Estuary, including Little Bay where beds killed by the wasting disease have not recovered in over 10 years. Eelgrass restoration projects have also been undertaken in Rye Harbor and the Piscataqua River adjacent to the State Port Facility expansion.

Recreational and Commercial Uses

Recreational Tourism and Boating

Tourism and recreation are important to the Seacoast economy. Tourism is the region's second-largest industry, with over 15% of jobs tourism-related. Important recreational activities include boating, fishing and shellfishing, sailing, day cruises, and tours. Boating has grown in popularity since the 1980s, with over 8,500 boats registered for tidal waters in 1992. Annual mooring permit sales grew dramatically in the 1980s and into early 1990s, but have leveled off since the NH Port Authority implemented a harbor management plan. Canoeing, rowing, kayaking, and windsurfing are also popular activities in the estuaries.

Annual mooring permit sales by the New Hampshire Port Authority: 1976-1996



Commercial Fishing

The American lobster is the most important commercially harvested species in New Hampshire, yielding about $16 million annually. Lobsters migrate into the estuaries during late spring, with some moving well into Great Bay during the summer. Despite fishing pressure in estuarine and ocean areas from 300 lobster fishers, landings remained relatively stable during the 1990s, averaging almost 1.6 million pounds annually from 1992 to 1997. In 1996 a summer oil spill and an October salinity drop caused by a particularly heavy rainfall event (greater than 12 inches of rain in two days in some areas) had negative impacts on lobsters, particularly those in traps at the time of the events. Mortality estimates are not available, but slightly lower 1997 lobster catches may be partly due to these events.

Landings of cod and winter flounder, also important to New Hampshire's commercial fishing fleet, consistently declined from 1992 to 1997. Spiny dogfish, shrimp, sea urchin, and other species have gained importance to the state's fishing industry. Recent catch records suggest that these species may also be succumbing to increased fishing pressure.

Recreational Fishing

Recreational fishermen pursue a variety of species, including striped bass, bluefish, salmon, mackerel, tomcod, flounder, shad, and smelt. In addition to boat access, numerous shore and bridge locations are used for fishing. Several charter boat companies in the Great Bay and Hampton-Seabrook estuaries take fishermen to inshore and offshore locations. Almost 150 recreational lobstermen set traps throughout the Great Bay and Hampton-Seabrook estuaries. A 1990 NH Fish & Game study estimated 88,000 saltwater anglers spent over $52 million dollars on fishing-related expenses.

NHEP

Striped bass fisherman

Recreational Shellfishing

Recreational shellfishing is an important part of the history and tradition of coastal New Hampshire, with its almost 250 miles of tidal shoreline. Softshell (steamer) clams and oysters are the principal quarries of recreational harvesters, but other shellfish species are also sought. Oysters are primarily harvested from the Great Bay Estuary, while softshell clams are primarily dug from the Hampton-Seabrook Estuary. In 1994 almost 3,000 clamming licenses were sold to New Hampshire residents, while oyster harvesters numbered nearly 1,000. A UNH study in 1992 estimated that recreational clamming in the Hampton-Seabrook Estuary contributed nearly $3 million to the state and local economy.

However, over half the shellfish-growing waters in New Hampshire's estuaries remain closed to harvesting. Shellfish beds are closed due to bacterial contamination, and due to insufficient monitoring to declare areas open and shellfish safe for human consumption. The impacts of wastewater treatment plant overflows, stormwater/sewer cross connections, and stormwater runoff require closure of beds after even small amounts of rain. This demonstrates the links between human activity in the watershed, water quality, and shellfish sanitation.

The NHEP is using shellfish in a number of ways to achieve its water quality goals. First, shellfish are used to directly measure water quality improvements. As estuarine water quality improves, more shellfish beds reopen. Second, shellfish are recognized as a tangible, understandable, and reliable indicator of overall environmental health. Thriving populations of shellfish typically indicate that other estuarine species are also healthy, and help to improve water quality by filtering estuarine water. Finally, the NHEP seeks to reopen as many of the state's closed beds as possible for citizens who enjoy harvesting this public resource.